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Description**1. Title of the Invention**

Exposure and Printing Apparatus for Production of Integrated Circuit with
Illuminometer

2. Scope of Patent Claims

1. An exposure and printing apparatus for production of integrated circuits
including illumination light projecting means and a sample stage being able to move
two-dimensionally, comprising:

an illuminometer for measuring light intensity on an exposure surface by the
illumination light projecting means, which is disposed in the sample stage in such
manner that a wafer surface on the sample stage coincides with a light detecting
surface substantially.

2. The apparatus as set forth in Claim 1, wherein the illuminometer measures
light passing through a micro aperture provided in a light shielding member.

3. The apparatus as set forth in Claim 1, wherein the illuminometer comprises
a one-dimensional or two-dimensional photo sensor.

3. Detailed Description of the Invention

The present invention relates to an exposure and printing apparatus for production of integrated circuits (ICs) with an illuminometer for measuring light intensity and intensity distribution on an exposure surface by illumination light projecting means.

The exposure and printing apparatus for production of ICs is usually required to have high uniformity of illumination. In recent years, the degree of integration of ICs has become higher and higher up to a pattern line width of about 1 μm . With the increase of the integration degree of ICs, the irregularity of the pattern line width or control of the line width is directly affected by irregularity of the illumination.

In principle, the light intensity of the exposure surface and an illumination part is simply measured by an illuminometer provided on the illumination part. To obtain intensity distribution in the exposure surface, it is enough to move the illuminometer having minute dimension one-dimensionally or two-dimensionally, or to measure light intensity distribution at the several points, in the illumination part.

However, in the prior art, the illuminometer is disposed in a space between the illumination light emitting part (for example, an emitting portion of a projection lens) and the sample stage to measure the light intensity of the exposure and printing apparatus. Also, to measure the intensity distribution, the illuminometer is mounted on a mounting table having a two-dimensional or one-dimensional moving mechanism. The light intensity or the intensity distribution measured as above is only that existing between the illumination light emitting part and the sample stage, not the data on a wafer surface on which a pattern is actually to be printed. Furthermore, the recently developed exposure and printing apparatuses are generally complicated in structure, and some of these known apparatuses have no space available for mounting the illuminometer with or without the moving mechanism.

For the reasons described above, in order to perform a real measurement, it is necessary to disassemble part of the exposure and printing apparatus and mount an illuminometer. That is, it is necessary to remove the sample stage or remove the whole illumination system and to mount the illuminometer by bringing the exposure surface and the measurement surface of the illuminometer to the same level.

Thus, the light intensity and intensity distribution are measured practically as a characteristic test of the illumination system at the time of manufacturing the apparatus. However, such a preliminary measurement is merely to measure a relative value at a position deviated or completely different from the position of the completed apparatus.

As described above, conventionally, there exists a disadvantage in that it is almost impossible to measure the real light intensity or intensity distribution in the actual exposure surface at any point in time.

Accordingly, it is an object of the invention to solve the disadvantages and to obtain an exposure and printing apparatus an illuminometer for production of ICs which enables easy measurement of real intensity of illumination light for printing and intensity distribution.

Hereinafter, the invention will be explained along with embodiments.

FIG. 1 shows an embodiment of the invention formed as a minifying projection exposure and printing apparatus for production of ICs. By the illumination light passed through a condenser lens 1, a minified image of an IC pattern on a reticle 2 is projected on a wafer 6 positioned on a sample stage 5 which is movable two-dimensionally, through a minifying projection lens 3. Reference symbol 4 in the figure is a pupil of the projection lens 3. In this manner, the wafer 6 is exposed to the IC pattern on the reticle 2. Further, an illuminometer 7 is embedded in the sample stage 5.

FIG. 2 is a plan view of the sample stage 5 as seen from above. The sample stage 5 includes an X-Y moving mechanism which is not shown and the position of the sample stage 5 can be determined in the order of about $0.02\mu\text{m}$ by an X-axis interference range finder 8 and a Y-axis interference range finder 9. The sample stage 5 can also be program-controlled using the positional information obtained by the interference range finders 8 and 9 by means of a computer which is not shown. In the embodiment, it is assumed that the maximum size of an exposure area 10 to be illuminated is in the order of about $10\text{mm} \times 10\text{mm}$ (to 14mm in diameter).

FIG. 3 is a sectional side view showing the illuminometer 7, the wafer 6 and the sample stage 5 in an enlarged manner. An upper surface of the illuminometer 7 is provided at a level substantially equal to an upper surface of the wafer 6. The illuminometer 7 has a hole (pin hole 7a) in order of about 0.5 mm in diameter as shown in the figure, and converts the light which has passed through the hole 7a into an electric signal by a photoelectric transducer element 12 to obtain the intensity. To measure the light intensity, the sample stage 5 is moved to position the illuminometer 7 below the exposure area 10 to perform the measurement. If the sample stage 5 is moved two-dimensionally under the exposure area 10 to measure the position of the sample stage 5 by the interference range finders 8 and 9, the light intensity distribution in the exposure area 10 can be easily determined.

FIG. 4 shows an example of the light intensity distribution obtained when the illuminometer 7 is moved in the direction of the arrow within the exposure area 10. The intensity distribution can also be obtained two-dimensionally by moving the sample stage 5 two-dimensionally.

The present embodiment illustrates the example using the sample stage with interference range finders. However, instead of using interference range finders, other

measuring means for obtaining positional information, such as a linear scale, may be attached.

The function of the pin hole 7a is to limit the light receivable area of the photoelectric transducer element 12 to a minute area, and the resolving power for measuring the light intensity distribution, that is, the size of the hole relative to the size of the exposure area 10 may be appropriately selected as desired. Further, the form of the hole is not limited to a pin hole, and a slit having a very small width also may be formed in a light shielding plate which shields the light receivable area of the photoelectric transducer element.

Meanwhile, in the present invention, since the light intensity and the intensity distribution in the illuminated exposure area 10 can always be identified, this can be employed for the judgment of deterioration of an illumination lamp. Conventionally, the deterioration of the lamp has been judged by measuring the light intensity of a part of illumination light or a part which is not used for the exposure, or replacement of the lamp has been performed by determining the useful life based on only lighting time. In the measurement of the former method, since a part of an end of the illumination light or the outside thereof is generally monitored, there frequently occurs a difference with a value of the light intensity actually used for the exposure. Further, the latter method is merely a rough estimation. However, with the exposure and printing apparatus including the illuminometer according to the embodiment of the invention, since the real light intensity, that is, light intensity on the exposure surface can be measured, this value can be used for the determination of deterioration of a lamp.

In the exposure and printing apparatus, it is a common practice to control the respective operations of the apparatus by using a computer. Therefore, if a program for measuring the light intensity distribution is incorporated in advance in a computer, it is possible to measure the light intensity and intensity distribution on an exposure surface during the suitable operation of the exposure and printing apparatus (for example at the step of wafer replacement), and to know the change of intensity distribution with time. In addition, by moving the sample stage 5 in such a manner as to move the pin hole 7a of the illuminometer 7 along a diagonal line of the exposure area 10, there can also be obtained data as to the uniformity of illumination light on the exposure area 10, simultaneously with measuring the intensity distribution (characteristic as shown in FIG. 4) through computer processing of the obtained intensity distribution. This illuminator is also used to confirm a real size of the exposure area of the reticle. That is, the illuminometer 7 is moved to detect the rise and fall of the light intensity distribution characteristic (FIG. 4), and on the basis of the positional coordinates (determined by the interference range finders 8 and 9) of the sample stage 5 at that time, the real size of the exposure area, that is, the size of the real pattern printing area, may be measured. This measurement is very effective

to ascertain whether or not the surrounding area of the reticle is completely shielded when the effective area (pattern area) of the reticle is small (a case where the exposure area on a wafer becomes smaller than a square of 10 mm × 10 mm) and a reticle aperture (shielding plate frame for opening only a pattern area of the reticle) shields the surrounding area of the reticle against light.

In addition, as other embodiments, a one-dimensional or two-dimensional photo sensor 11 or 12 may be used as shown in FIGS. 5(A) and 5(B). In a case where the one-dimensional photo sensor 11 is used, the sample stage 5 may be only moved in a direction intersecting, at a right angle, the longitudinal direction of the photo sensor 11. Furthermore, in a case where the two-dimensional photo sensor 12 is used, the light intensity distribution can be obtained merely by electrically scanning the photo sensor 12 after moving the sample stage 5 up to the position at which the photo sensor 12 falls within the exposure area 10.

According to the invention described above, there is an advantage that since the illuminometer is embedded in the movable stage, the light intensity distribution can be easily obtained at an arbitrary point in time without disassembling or stopping the apparatus. Further, there is also an advantage that since the wafer surface which is actually exposed is at a level equal to the measurement surface of the illuminometer, the real light intensity and intensity distribution can be obtained in entirely the same condition as that of exposure.

4. Brief Description of the Drawings

FIG. 1

FIG. 1 is a view showing a principle according to an embodiment of the present invention.

FIG. 2

FIG. 2 is a plan view of a sample stage.

FIG. 3

FIG. 3 is an enlarged sectional view showing an area where an illuminometer shown in FIG. 1 exists.

FIG. 4

FIG. 4 is a graph showing light intensity distribution.

FIG. 5

FIG. 5(A) shows an example using a one-dimensional photosensor as the illuminometer and FIG. 5(B) shows an example using a two-dimensional photosensor as the illuminometer.

Description of Symbols of Main Parts

Sample Stage 5

Illuminometer 7, 10, 12

Minute Opening 7a

Fig. 4

Quantity of light
Position